

Red and Bonita Mine

Removal Action – Bulkhead Plan Summary

May 2015



Mine Discharge and Underground Workings

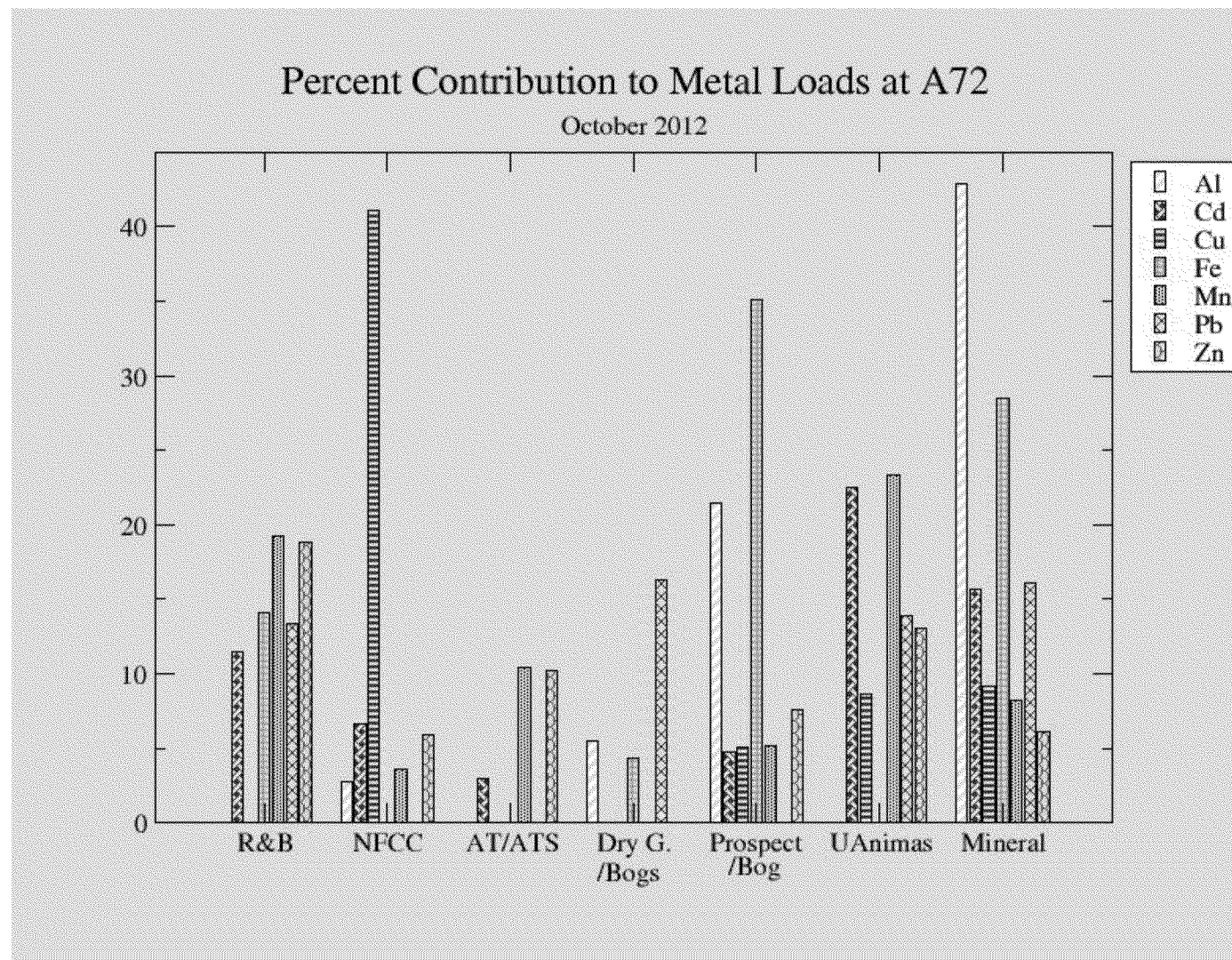
- Flow is approximately 200 to 300 gpm
- Zinc concentration is consistently near 16,000 ug/L
- Cadmium concentrations are near 30 ug/L
- Iron concentration is approximately 93,000 ug/L
- pH ranges from 5.5 to 6 su.
- Underground workings are estimated at 3000 to 3500 ft.
- EPA and DRMS were able to access approximately 2000 ft in 2013

Adits Flows in Cement Ck from 2005 to 2012

Mine Adit Discharge 2005 to 2011

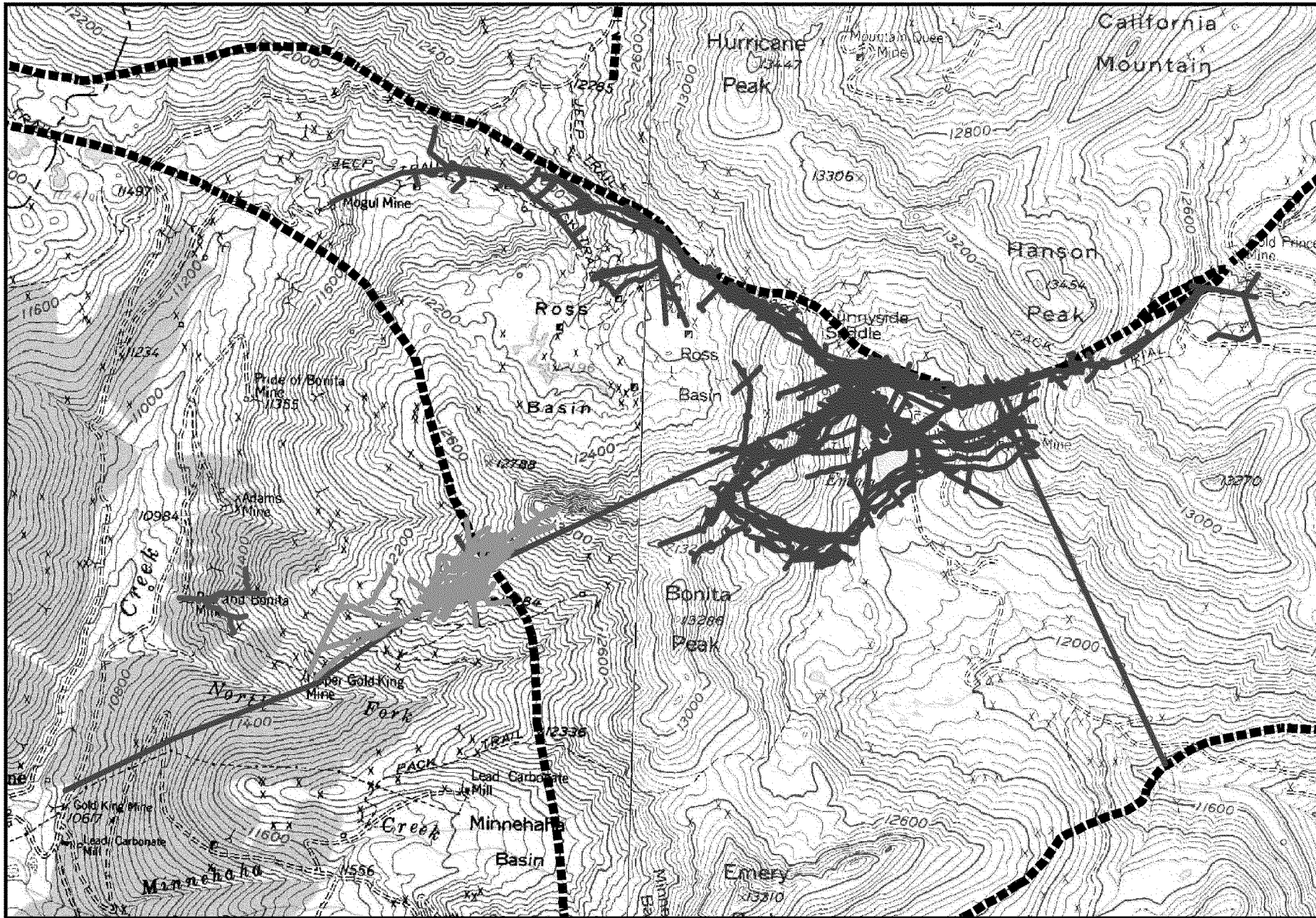
| Mine | Elevation (feet AMSL) | Bulkhead Install | Flow Rate (gpm) | | | | | | |
|--|-----------------------------|----------------------|-----------------|-------------------|-----------------|-----------------|-----------------|-----------|------------|
| | | | July 2005 | September 2005 | October 2006 | Average 2010 | Average 2011 | July 2012 | Oct 2012 |
| Mogul (pH 3.5) | 11,376 | 2003 | 21 | 27 | 11 | 54 | 56 | 128 | 90 (?) |
| Gold King 7 Level (pH 2.5 to 5) | 11,386 | None | 42 | 135 | 314 | 206 | 140 | 128 | 55 – 85 |
| Red & Bonita (pH 6) | 10,893 | None | 210 | 224 | 233 | 216 | 319 | 314 | 202 |
| American Tunnel (pH 5) | 10,540 | 1997 2001 2002 | 95 | 90 | 84 | 101 | 101 | 193 | 103 |

USGS - Part IV: Results – Loads & Sources

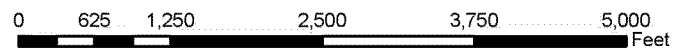


Adit Loading Analysis Conclusion

- Red and Bonita contributes approximately 18% of the Zn and 12% of the Cd load in Oct 2012 in the Animas at A72 (relative source contributions vary seasonally)
- The flow from Red and Bonita averages approximately 300 gpm and appears to have stabilized since the Am Tnnl plugs
- Zn and Cd are two of the primary contaminants of concern based on the Screening Level Ecological Risk Assessment
- No other single mine source contributes as much Zn in either Cement Ck or the Animas
- USGS reactive / transport modeling indicates that the Zn from R n B adit is conserved in transport to A72



Prepared by Kirstin Brown, CDRMS, 1/21/2014



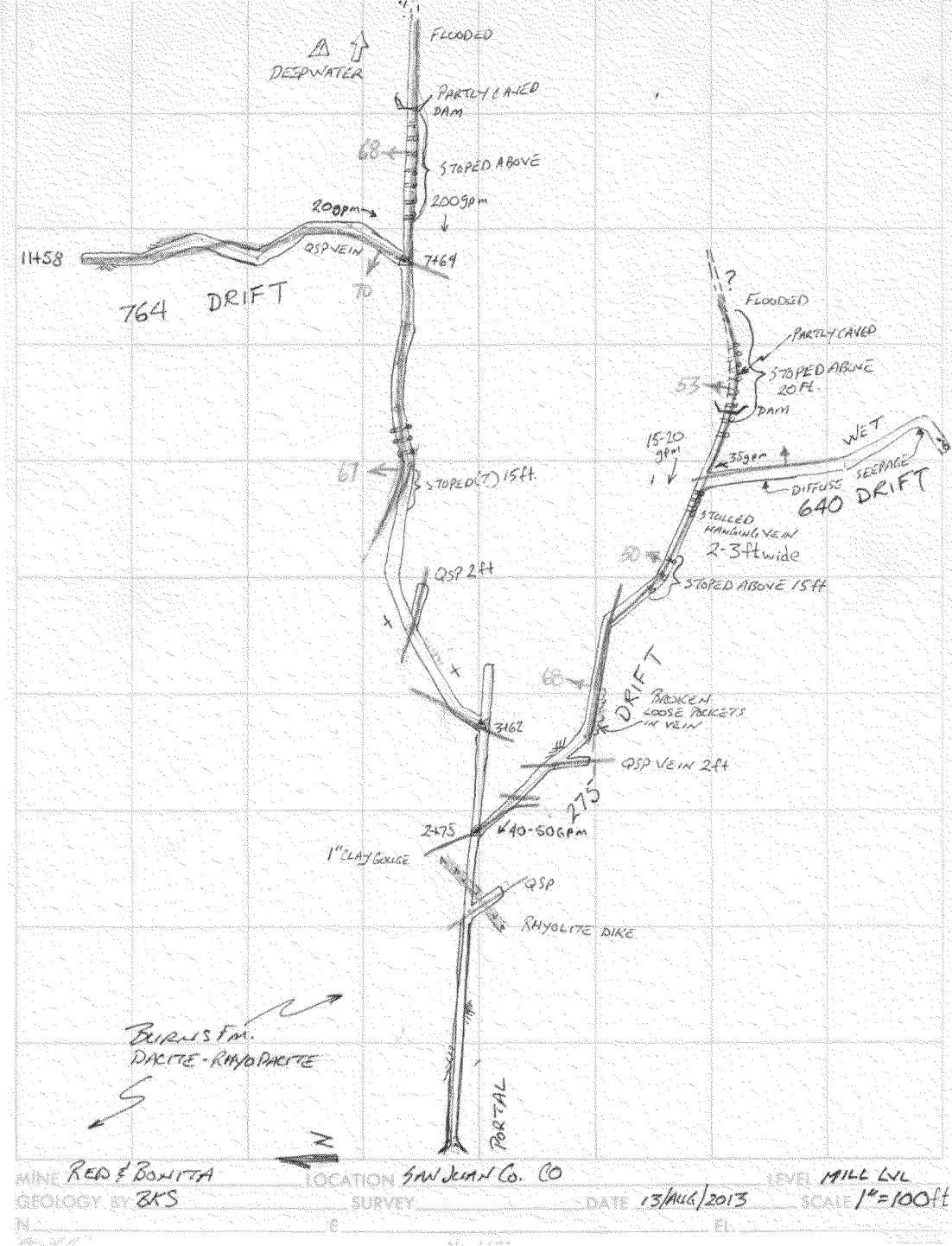
RED AND BONITA MAP
 Mine Workings past cave-ins are only projected to line of sight
 SUNNYSIDE WORKINGS
 Most Recent workings, needs more work
 GOLD KING WORKINGS
 There is more data that needs to be added on 7 Level

Legend

- R & B Workings (Stover)
- GoldKing1thru7
- SunnysideWorkings
- USGS Mapped Faults PP 1651







Design Factors and Investigation Results

- Underground Investigations – rock conditions and workings extent
- Rock Quality: American Tunnel (Burns Member) cores & rock hardness results
- Secondary permeability index- packer tests in Red and Bonita at the bulkhead location – effectively impermeable / 1.54×10^{-14} L/m²
- Overburden elevation at bulkhead site ~ 196 feet
- Hydraulic fracturing and hydraulic jacking/fractures
- Probable head pressures analysis

Mine Elevations/Bulkheads/mine pool elevations

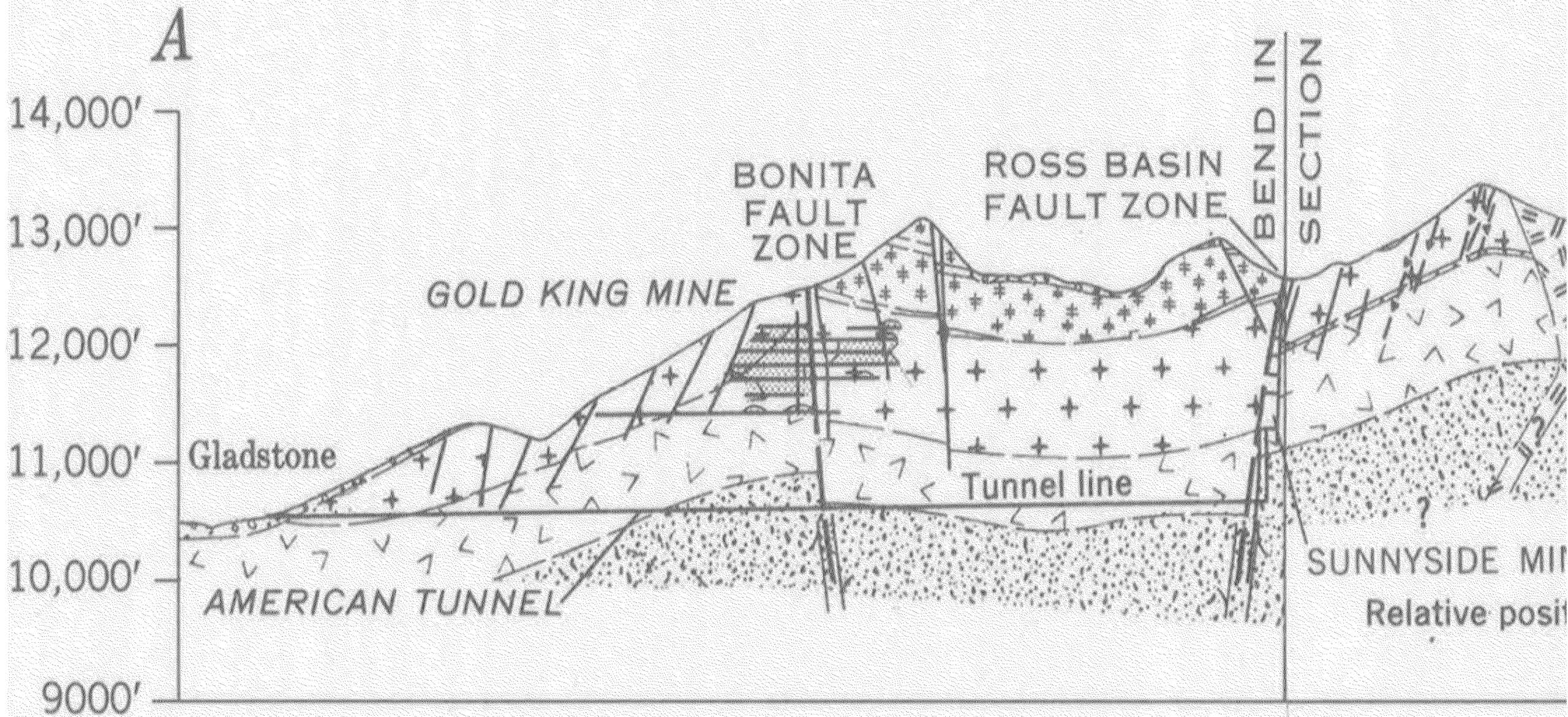
| DATE | Mine & Bulkhead Status & Pressure (psi) | Elevations |
|--|---|--------------------------------|
| 9/xx/1994 ? | Terry Tunnel Bulkhead #1 – constructed | Portal 11,554 ft |
| 9/9/1996 | American Tunnel Bulkhead #1 - closed | Portal 10,660 ft |
| | Red and Bonita Mine Portal | Portal 10, 957 ft |
| | Mogul Mine – bulkhead | Portal 11,400 ft |
| | Gold King Level #7 | Portal 11,440 ft |
| American Tunnel Bulkhead #1 Pressure Gauge | | |
| 9/3/1997 | 312 | Mine Pool elev. 11,380 feet |
| 8/28/1998 | 359 | Mine Pool elev. 11,488 feet |
| 9/24/1999 | 415 | Mine Pool elev. 11,618 feet |
| 10/10/2000 | 440 | |
| 12/4/2000 | 438 | Mine Pool elev. 11,671 feet |
| 3/27/2001 | 438 | |
| 5/14/2001 | 438 <u>Final Pressure</u> | Final <u>Measure 11,671 ft</u> |

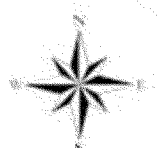
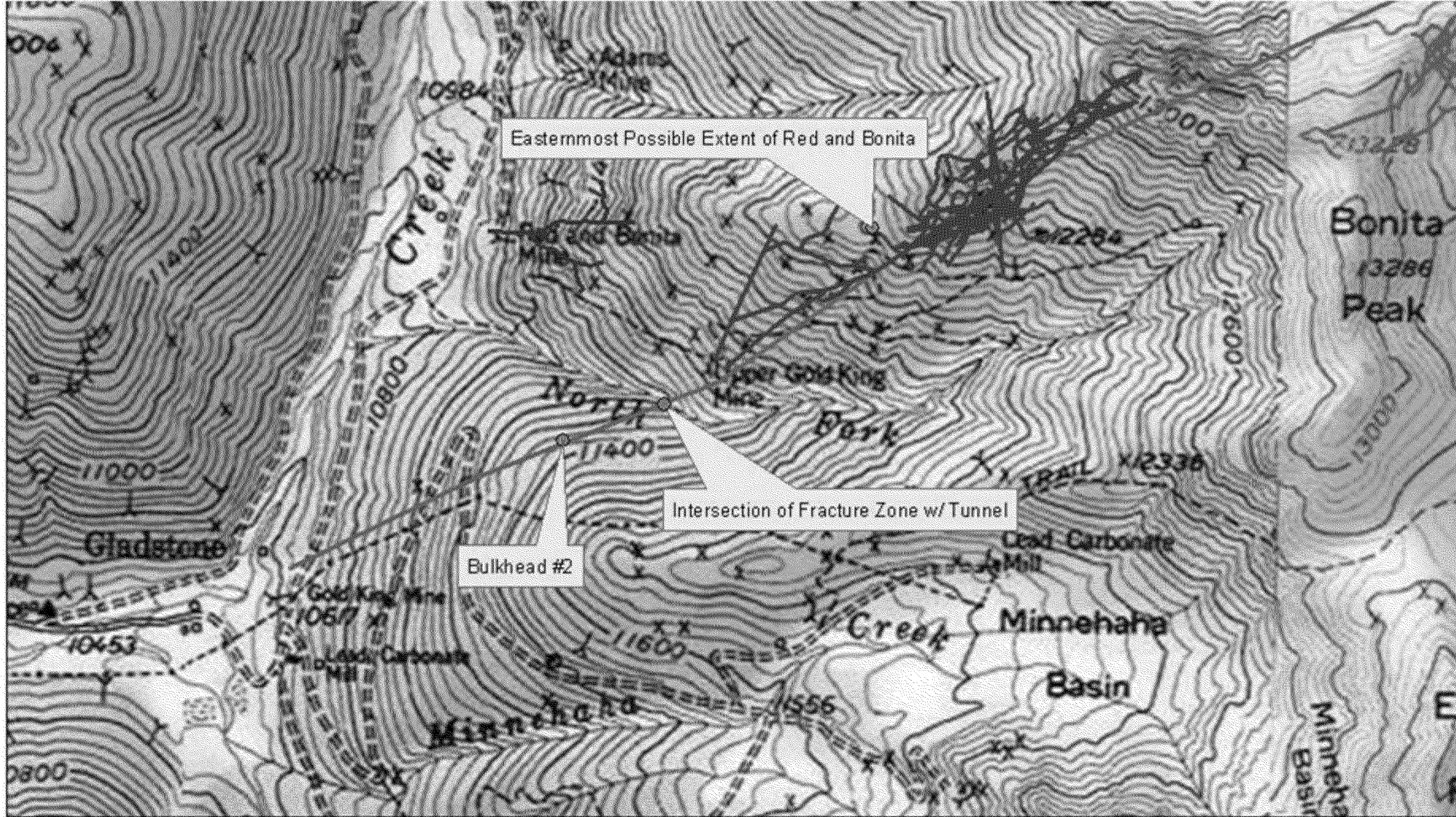
Water Elevations / Pressure Heads / Rock Thickness

| Pressure Head | Water Pressure | Required Rock Thickness |
|---------------------------------|----------------|-------------------------|
| 1253 feet (Lake Emma) | 543 psi | 237 feet |
| 714 feet (Sunnyside Mine Pool) | 309 psi | 135 feet |
| 500 feet (Probable Head) | 217 psi | 95 feet |
| 1037 feet (hydro-fracing Point) | 449 psi | 196 feet |

Water Elevations and Bulkhead Pressures

- American Tunnel bulkhead #2: constructed for a maximum water head of 640 feet, equating to a water table at 11, 251 feet elevation
- bulkhead #2 pressure equilibrated at 11,015 feet elevation when the water intersected an outlet to surface via the Red and Bonita mine, elevation 10, 957 feet.
- Red and Bonita bulkhead - potentially cause an increase in ground water to the 11, 251 feet, which is the projected Am Tn #2 pressure.
- At 11,251 ft, the pressure head of 294 feet (127 psi) at the Red and Bonita bulkhead.
- The next pathway for ground water to surface would be at the Gold King level #7, 11, 440, which would create a pressure head of 483 feet (209 psi) at the Red and Bonita bulkhead.





5/14/2015

Upper Cement Creek



Legend

- Mogul and Grand Mogul
- Red and Bonita
- Gold King
- Dunsyde

Red and Bonita Bulkhead Design Basis – analysis and results

- 6 foot long bulkhead (reinforced) will perform adequately under a pressure head of 500 feet (217 psi), which is Gold King – 7 level plus
- 15 foot long bulkhead (reinforced) will perform adequately under a pressure head of 1253 feet (543 psi), which is the pressure head that would occur on the Red and Bonita mine if the Sunnyside mine pool were to climb to the Lake Emma outlet elevation.
- While this scenario is considered highly unlikely, EPA and CIMRP determined that it is prudent to construct the Red and Bonita bulkhead to this conservative standard. (The cost difference is small.)
- This is true even in the case of a potential Gold King mine bulkhead.
- This design uses the methodologies detailed in Einarson and Abel (1990) and Lang (1999) for maximum hydrostatic head at the bulkhead of 1253 feet and an earthquake acceleration of 0.185 g.

Red and Bonita Bulkhead Design Spreadsheet

| | B1 | | | | | | | |
|----|---|--|---------------------------------------|-----------------------|---------------------------------|-------------------------------|---|---|
| | A | B | C | D | E | F | G | H |
| 1 | Punching Shear Design | | | | | | | |
| 2 | | | | | | | | |
| 3 | Inputs: | *Change values on Input Tab* | | | | | | |
| 4 | Concrete Compressive Strength (f_c) | 3,000 | psi | | | | | |
| 5 | Bulkhead Height (h_b) | 10 | ft | | | | | |
| 6 | Bulkhead Width (w_b) | 7 | ft | | | | | |
| 7 | Design Head (H) | 1253 | ft | | | | | |
| 8 | Water Density (γ_w) | 62.4 | pcf | | | | | |
| 9 | Fluid Static Load Factor (ϕ_{fs}) | 1.4 | | | | | | |
| 10 | Factored Water Hammer Pressure (P'_H) | 115,103 | lb (Calculated from Water Hammer Tab) | | | | | |
| 11 | | | | | | | | |
| 12 | Calculations: | | | | | | | |
| 13 | Concrete Shear Strength (f_{cs}) | $f_{cs} = 2 * f_c^{1/2} =$ | 109.5 | psi | | | | |
| 14 | Static Fluid Load on Bulkhead Face (F_s) | $F_s = H * \gamma_w * h_b * w_b =$ | 5,473,104 | lb | | | | |
| 15 | Factored Static Fluid Load on Bulkhead (F'_s) | $F'_s = F_s * \phi_{fs} =$ | 7,662,346 | lb | | | | |
| 16 | Length of Bulkhead Required for Shear (L_s) | $L_s = F'_s / (2 * (h_b + w_b) * f_{cs} * 144)$ | 14.29 | ft | | | | |
| 17 | | | | | | | | |
| 18 | Earthquake Consideration (Water Hammer): | | | | | | | |
| 19 | Length of Bulkhead Required (L_s) | $L_s = (F'_s + P'_H) / (2 * (h_b + w_b) * f_{cs} * 144)$ | 14.50 | ft | | | | |
| 20 | | | | | | | | |
| 21 | | | | | | | | |
| 22 | | | | | | | | |
| 23 | | | | | | | | |
| 24 | | | | | | | | |
| 25 | | | | | | | | |
| 26 | | | | | | | | |
| 27 | | | | | | | | |
| 28 | | | | | | | | |
| 29 | | | | | | | | |
| 30 | | | | | | | | |
| | Inputs | Water Hammer | Hydrofrac | Punching Shear Design | Plain Concrete Deep Beam Design | Reinforced Concrete Deep Beam | | |

Red and Bonita Bulkhead Features and Specifications

- bulkhead dimensions are 6' x 8' x 15' long
- bulkhead volume is 27 cubic yards – this may require adjustment once bulkhead location is scaled and mucked
- low pressure grouting is necessary around the upper contact of the concrete with the roof of the adit
- flexural reinforcing at the bulkhead outby end is #9 bars on 9 inch centers and temperature shrinkage rebar at the bulkhead inby end is #6 bars
- eight inch stainless steel bypass and three-fourth inch monitoring piping will be installed
- Concrete will use sulfate resistant Type V cement, 559 lbs. per cubic yard of concrete and 240 lbs. fly ash, water/cement ratio of 0.52 by weight, and will include Xypex[®] admixture for waterproofing

Technical drawing of a gate structure cross-section, showing the AIR SIDE (left) and WATER SIDE (right). The drawing includes the following components and labels:

- AIR SIDE (Left):**
 - WECD (Water End Closure Device)
 - 6x8 POST
 - 3/4" DENSEF TUBE RING
 - 3/4" SCHEDULE 40 STAINLESS STEEL PIPE
 - 3/4" PLYWOOD OR PARTICLE BOARD
 - STEEL GATE VALVE
 - 3/4" X 1/2" (likely a typo for 3/4" x 1/2" or similar)
- WATER SIDE (Right):**
 - WECD (Water End Closure Device)
 - 6x8 POST
 - 3/4" DENSEF TUBE RING
 - 3/4" SCHEDULE 40 STAINLESS STEEL BYPASS PIPE
 - 3/4" PLYWOOD OR PARTICLE BOARD
- Central Components:**
 - 3/4" DENSEF TUBE RING
 - 3/4" THRUST PLATE (10'X10')
 - 3/4" THRUST PLATE (14'X14')
 - 3/4" SCHEDULE 40 STAINLESS STEEL BYPASS PIPE
- Structural Details:**
 - CAULK
 - 1/2" REBAR, TWO-WAY, 12" O-C
 - 1/2" REBAR, TWO-WAY, 2 INCH O-C
 - 1/2" FULLY RESIN-GROUTED THREADBAR, 3" EMBEDMENT
- Other Labels:**
 - 3/4" MAX CLEARANCE
 - 3/4" MAX CLEARANCE

COLORADO
Division of Reclamation,
Mining and Safety
Department of Natural Resources

Monitoring Pressure and Water Flow / Quality

- Pressure Monitoring – transducer and standard pressure gauge
- Bulkhead Sampling Port and Injection Line
- Water Flow and Quality Monitoring
 - Adits: Gold King, Mogul, American Tunnel, Gold Point, Adams and Silver Ledge
 - Surface Water: NFCC, bracket R n B reach CC03 & 03B, CC17 CC18B, CC18, C48, , Eureka Gulch, A72
 - Seeps/surveillance – R n B vicinity
- Visual inspection of the bulkhead and surrounding zone